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DEEP SPACE NETWORK CUSTOMER FORUM **JPL**

# ARTEMIS: A New Mission Using THEMIS B & C Spacecraft

Manfred Bester  
UCB



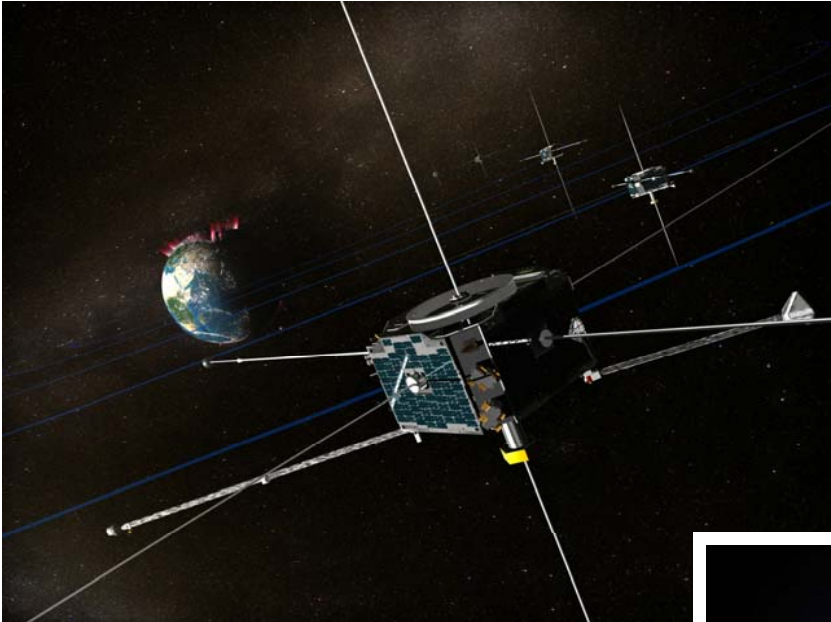
## Agenda

- THEMIS Mission Overview
- THEMIS/ARTEMIS Mission Extension
- ARTEMIS Concept of Operations
- ARTEMIS Science
- ARTEMIS Schedule



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### *Time History of Events and Macroscale Interactions during Substorms (**THEMIS**)*

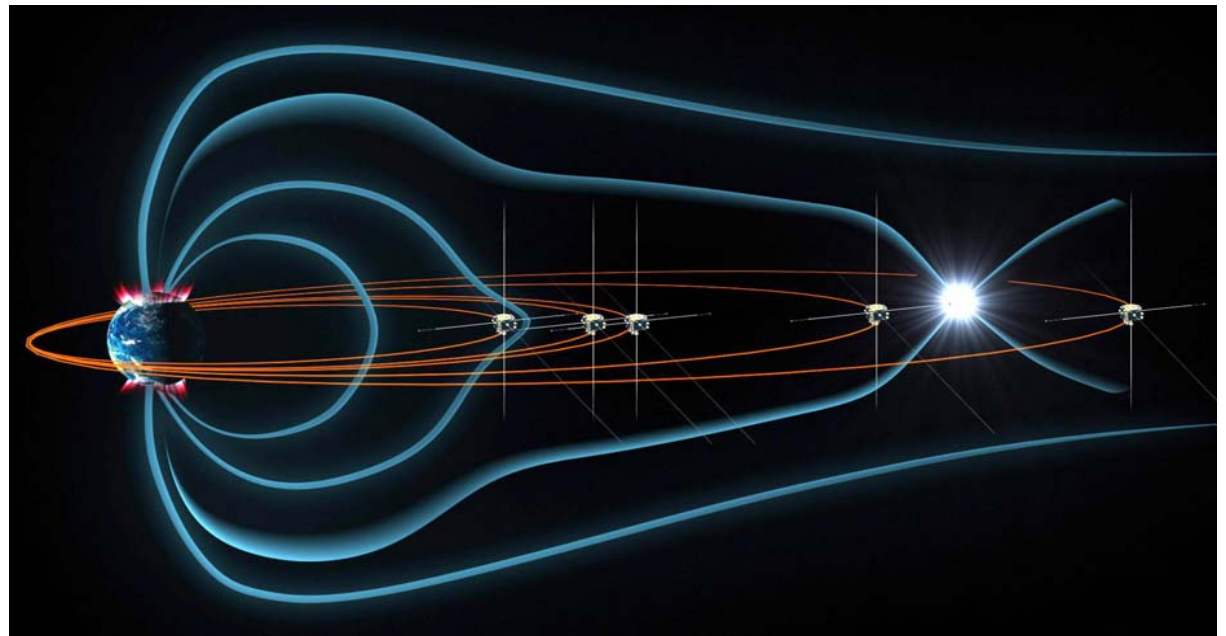
NASA Medium-class explorer mission,  
managed in PI Mode by UCB/UCLA

PI: Dr. Vassilis Angelopoulos

<http://themis.ssl.berkeley.edu>

5 Probes in synchronized  
Earth orbits with periods of  
4, 2 and 1 days

Conjunctions are formed in  
magnetospheric tail every  
4 days





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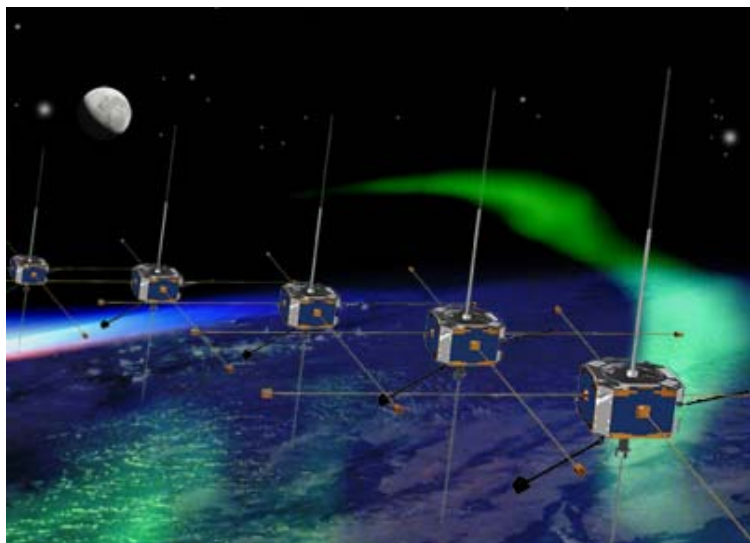
Launch:  
February 17, 2007



Probe release: L + 70 min



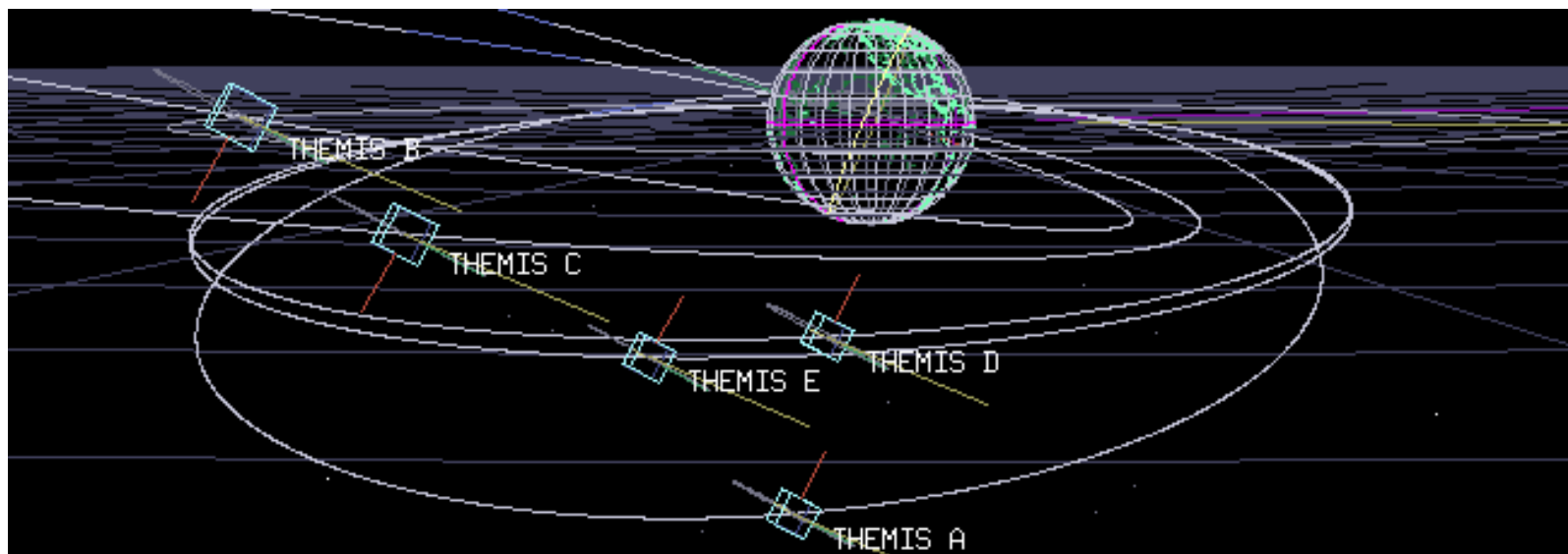
Responsibility for  
constellation  
operations  
transitioned to  
MOC at UCB



## Flight Segment

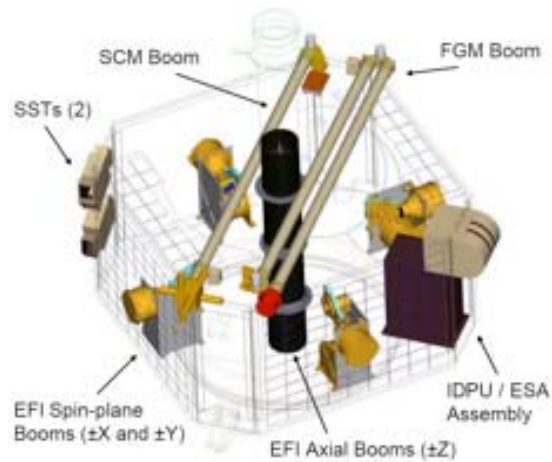
- Constellation of 5 identical spacecraft
- Spin-stabilized at 20 rpm
- Identical suite of 5 science instruments to measure fields, waves and particles
- Hydrazine blow-down propulsion system with 49 kg of fuel and total  $\Delta V$  capacity of 930 m/s, assuming 4 kg of fuel for attitude control
- S-band communications with 10 TLM data rates
- Two-way Doppler tracking and ranging for OD

Orbit view on  
Dec. 6, 2008





## Instrument Suite

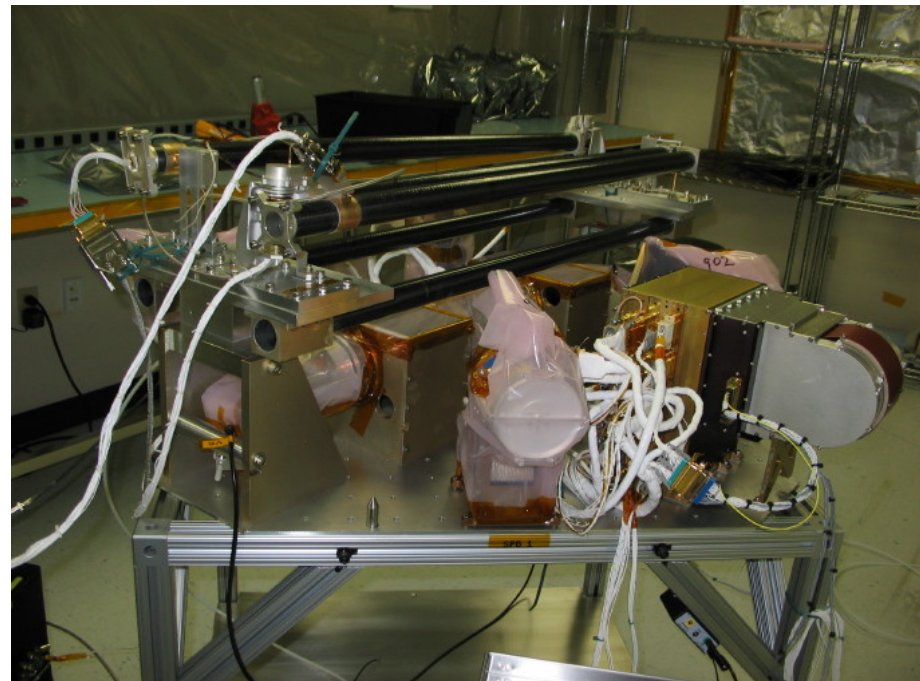


## Particle Instruments (2)

- Electrostatic Analyzer (ESA)  
Low-energy ions and electrons
- Solid State Telescope (SST)  
High-energy ions and electrons

## Fields and Waves Instruments (3)

- Fluxgate Magnetometer (FGM)  
DC and low-frequency magnetic fields
- Search Coil Magnetometer (SCM)  
AC magnetic fields
- Electric Field Instrument (EFI)  
Electric fields and waves





## Prime Mission Status

- Completed LEOP, *coast phase*, *tail 1* and *dayside 1* seasons
- Upcoming *tail 2* and *dayside 2* seasons
- Answered primary scientific questions already:  
What is the origin and time sequence of substorms?

## Constellation Status

- All probes very healthy and collecting science data
- Fuel reserves allow for ambitious mission extension

## Ground Systems & Operations Status

- All ground systems processing nominally
- Executed 253 individual thrust operations to date
- Completed 11,000 passes
- All routine passes supported in lights-out mode

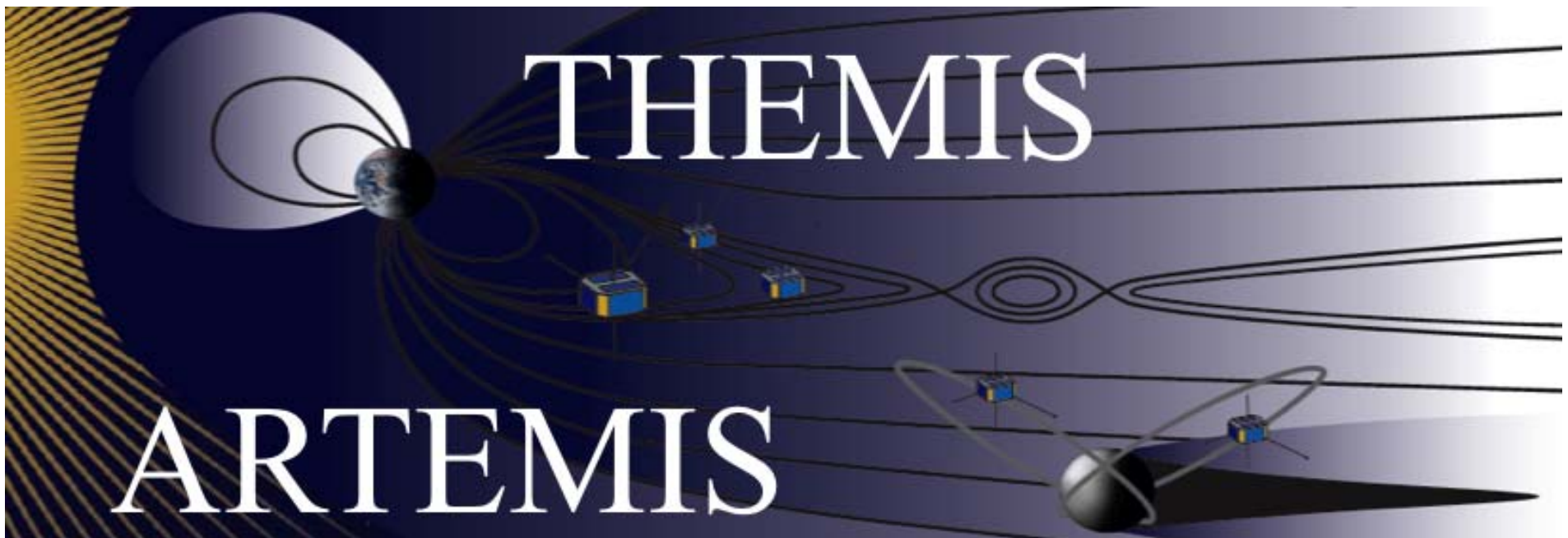


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## DEEP SPACE NETWORK CUSTOMER FORUM **JPL**

### *Time History of Events and Macroscale Interactions during Substorms (**THEMIS**)*

3 Probes (A/P5, D/P3, E/P4) in synchronized Earth orbits



### *Acceleration, Reconnection, Turbulence and Electrodynamics of the Moon's Interaction with the Sun (**ARTEMIS**)*

2 Probes (B/P1, C/P2) in lunar orbits





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# DEEP SPACE NETWORK CUSTOMER FORUM **JPL**

## ARTEMIS Operations Concept

Lunar orbit periods: ~1 day

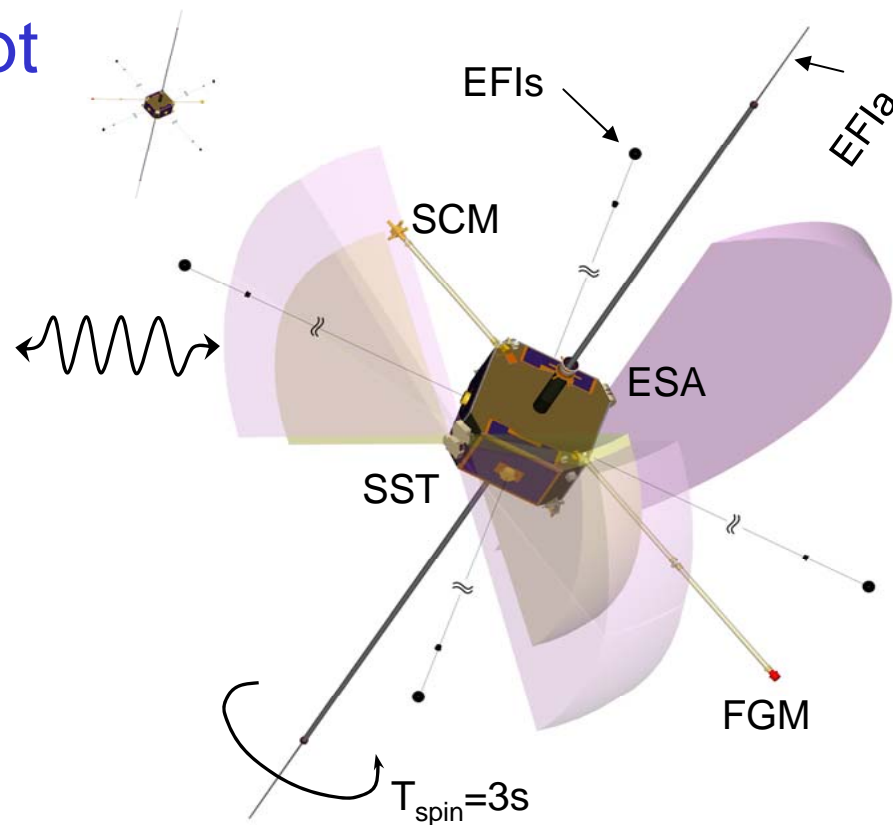
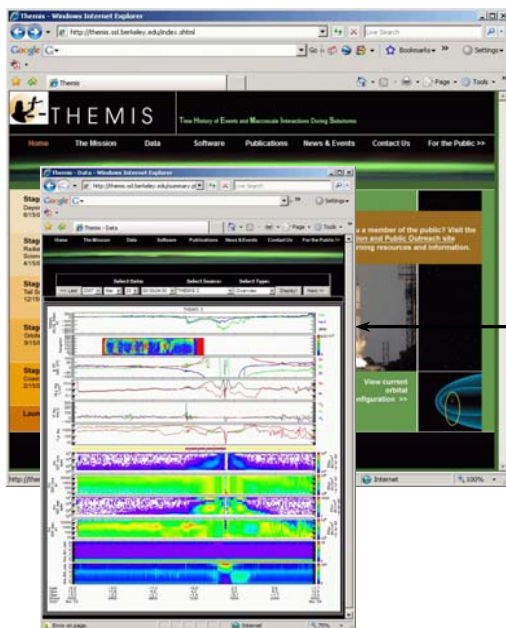
Data volume: 100 Mbits/day

DSN support:  
3.5 hrs daily

Data products:  
2 hr latency



Mission Ops  
*UCB*



### Science instruments:

**ESA:** Electrostatic Analyzer (3 eV - 25 keV; *Carlson & McFadden*)

**SST:** Solid State Telescopes (25 - 1000 keV; *Larson*)

**FGM:** Fluxgate Magnetometer (0 - 128 Hz; *Glassmeier, Auster & Baumjohann*)

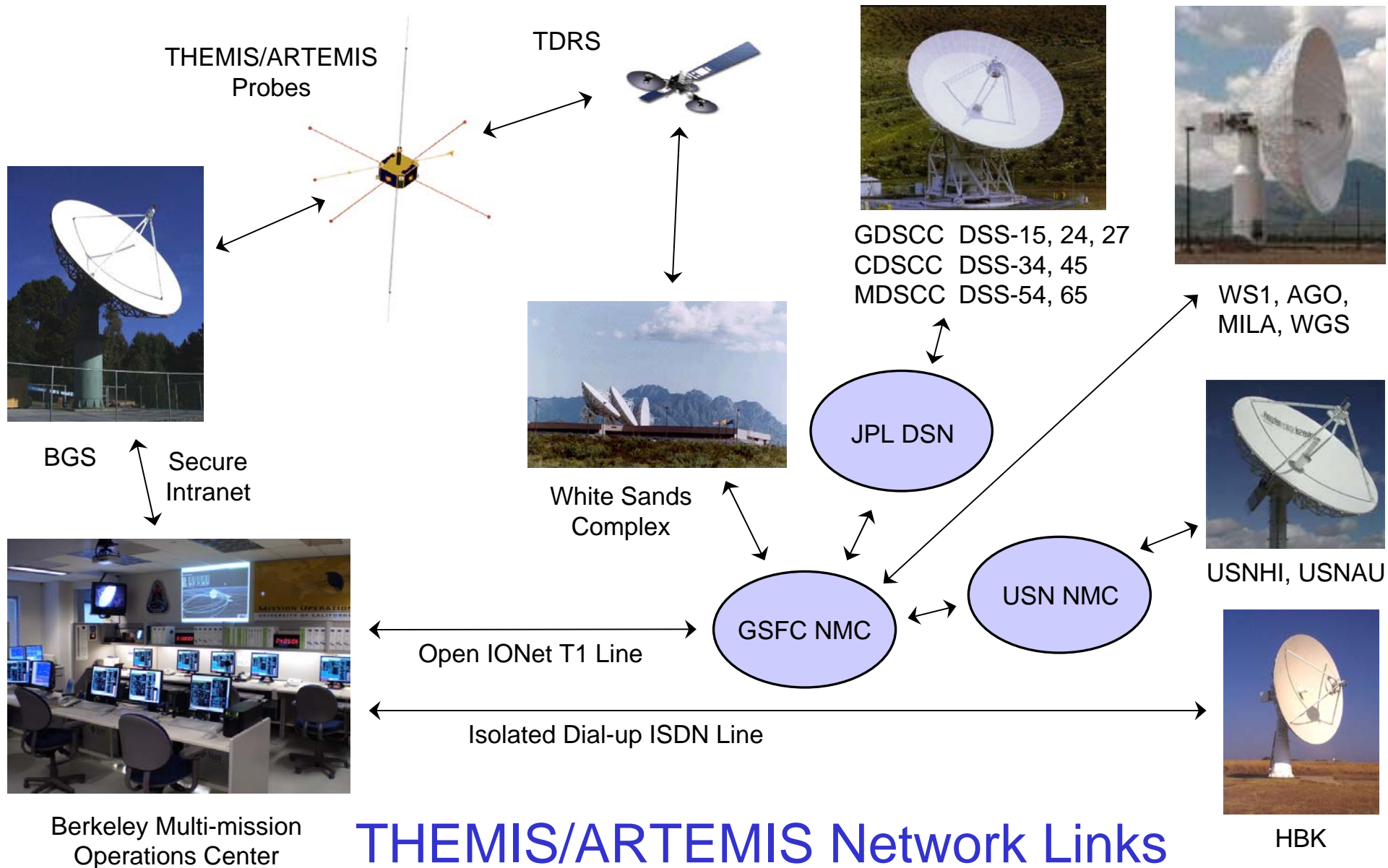
**SCM:** Search Coil Magnetometer (1 Hz - 4 kHz; *Roux & LeContel*)

**EFI:** Electric Field Instrument (0 - 8 kHz; *Bonnell & Mozer*)



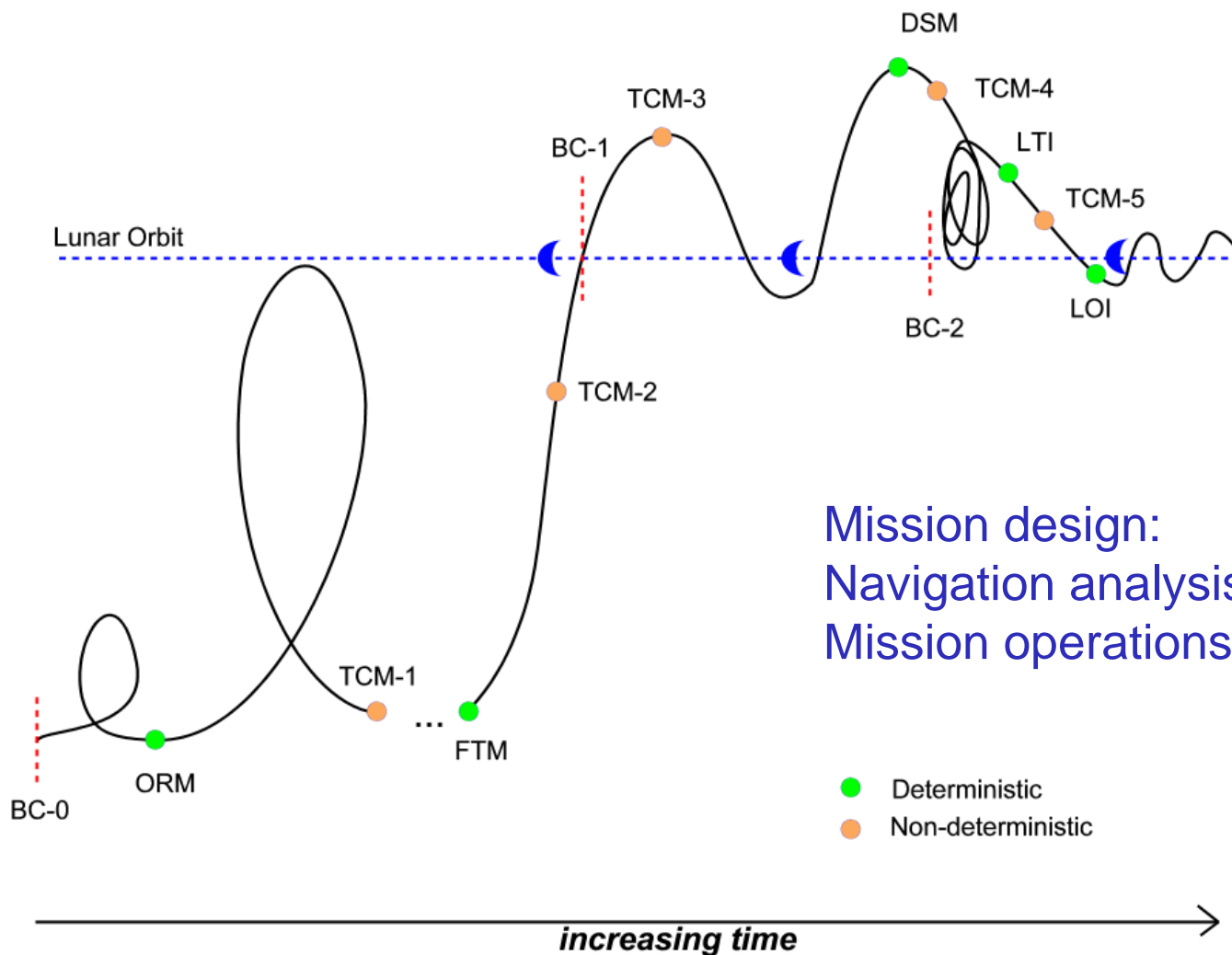
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# Lunar Transfer Scenario



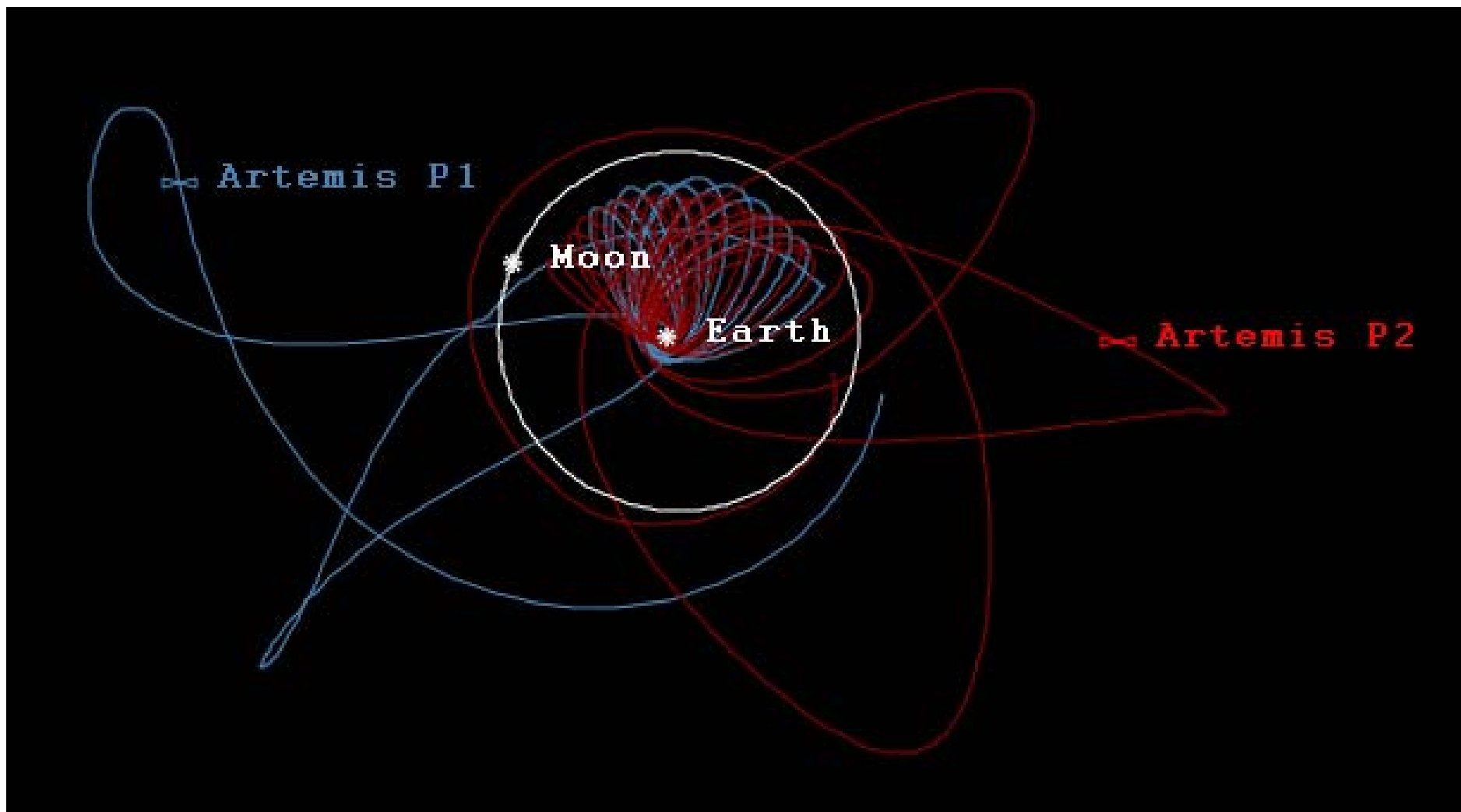
Mission design: JPL/GN&C  
Navigation analysis: GSFC/FDAB  
Mission operations: UCB/SSL



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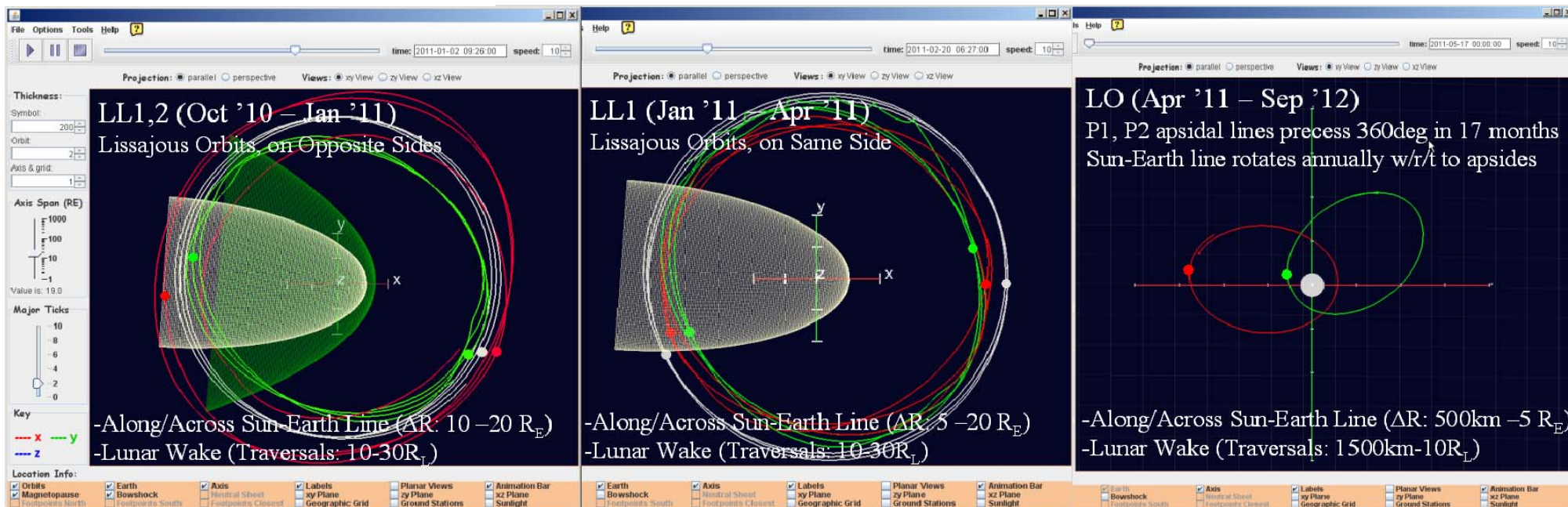
# ARTEMIS Trajectories





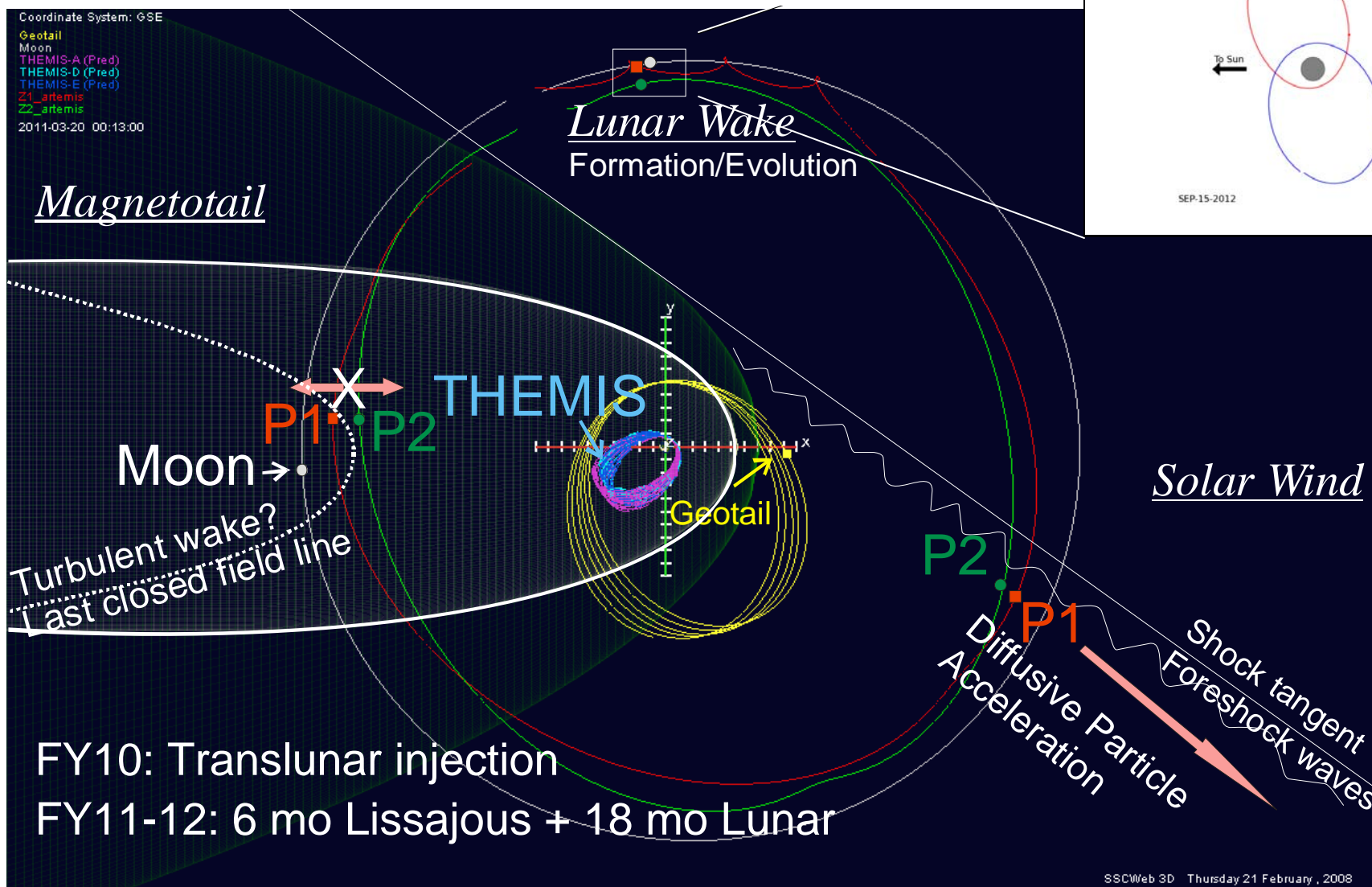
## ARTEMIS Mission Phases

Insertion: FY10    Science: FY11 - FY12





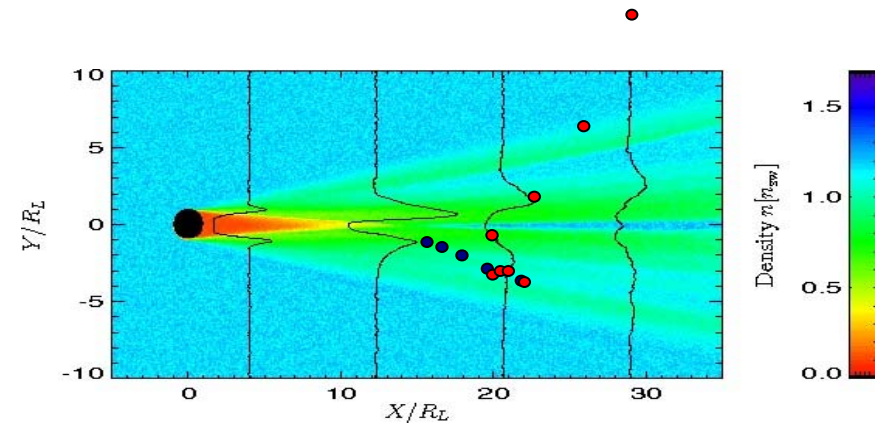
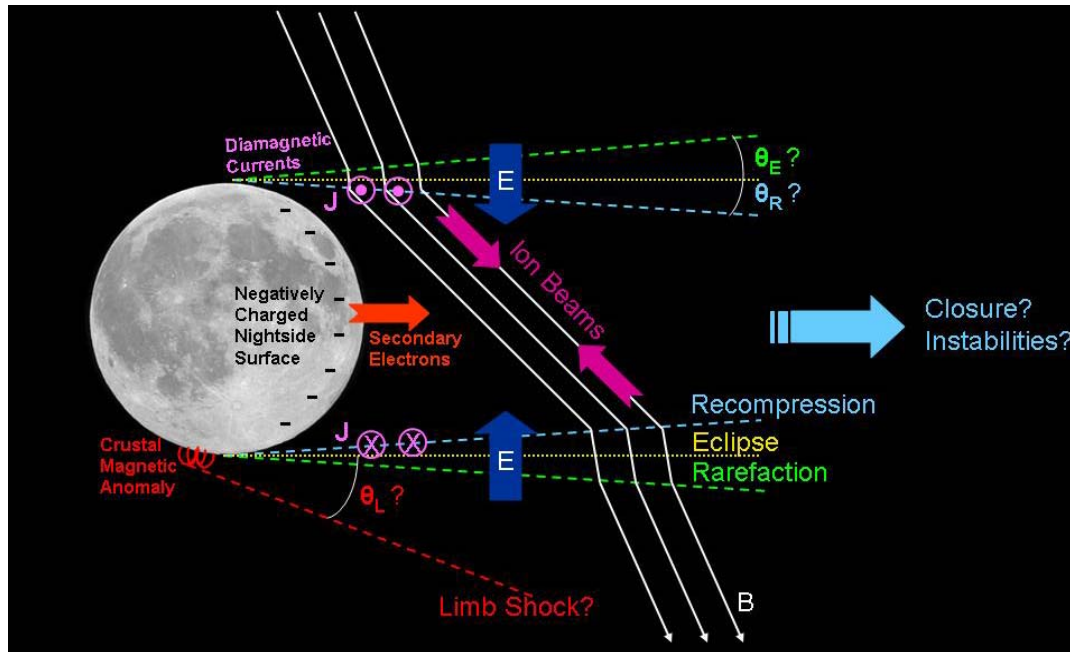
# ARTEMIS Heliophysics Objectives



SSCWeb 3D Thursday 21 February, 2008



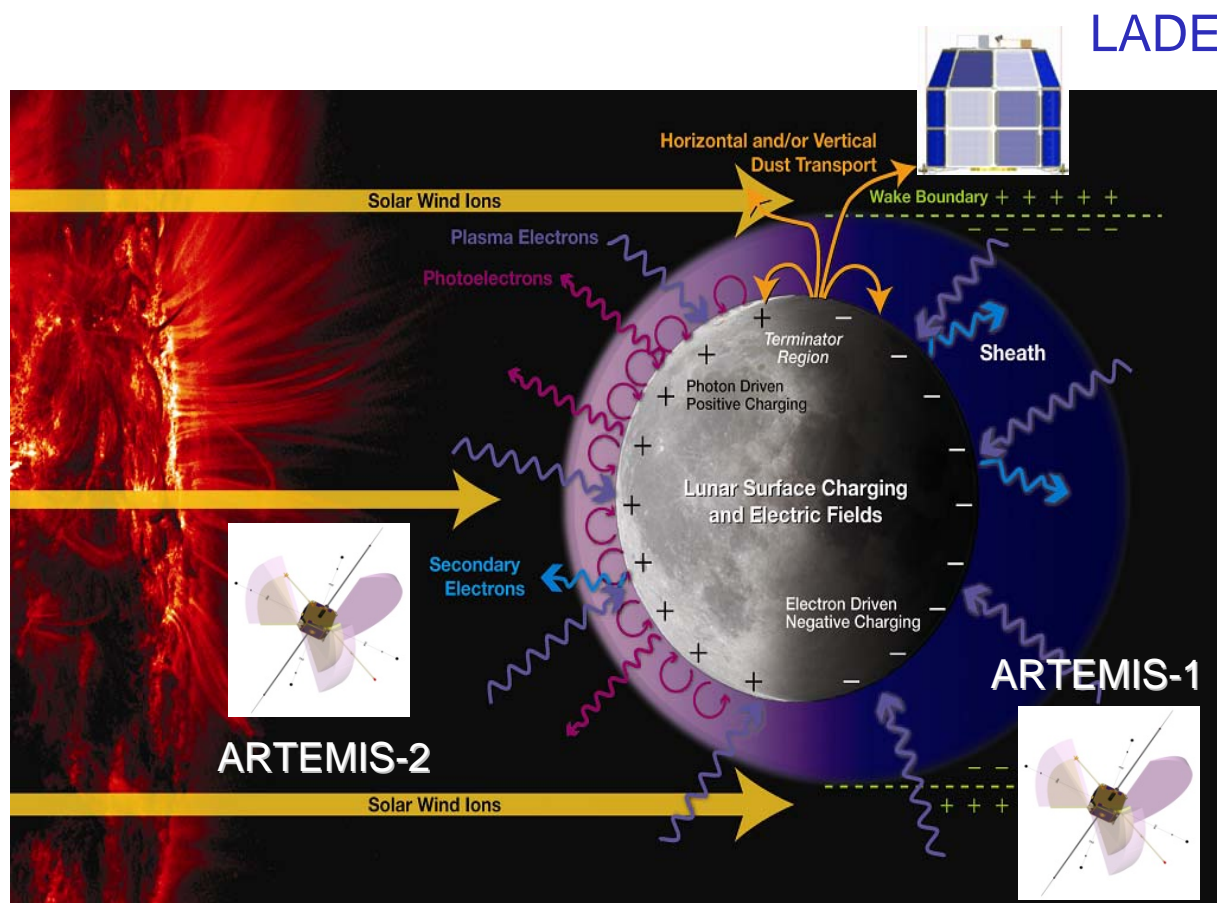
# Electrodynamic Environment of the Moon: Lunar Wake



- The Moon is an ideal plasma laboratory for studying magnetized plasmas.
- The simple geometry of the Moon and its absorbing boundary produces a system that can be readily modeled with computers.
- This allows the software to be tested and the physics to be understood.
- ARTEMIS measurements are particularly useful for such tests.



## Dust Levitation in Electric Fields



- APOLLO observers saw dust elevated above the lunar surface to possibly high altitudes.
- LADEE will probably have a dust detector, but has no capability of measuring the solar wind electric and magnetic fields.
- ARTEMIS measures the solar wind velocity, the interplanetary magnetic field and hence the solar wind electric field. It also can measure surface potentials with electron reflectometry.
- ARTEMIS plus LADEE will enable us to determine the response of charged lunar dust to the lunar and solar wind electric fields.



- Support of LRO

- ARTEMIS can provide comprehensive monitoring of Lunar Space Environment
- Complements LRO/CRATER providing measurements below 6 MeV
- ARTEMIS has already supported LRO to certify ground stations (WS1, USN)



- Support of NASA's Scientific Content of Exploration of the Moon

- Understand the lunar atmosphere

- Support of all missions

- ARTEMIS provides comprehensive monitoring of plasma conditions and lunar surface electric fields
- Allows study of the response of the lunar exosphere and dust to external drivers
- ARTEMIS provides solar wind monitoring

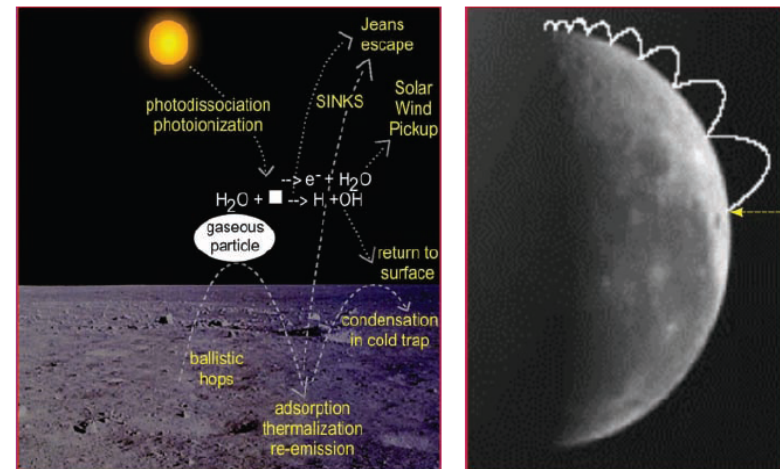
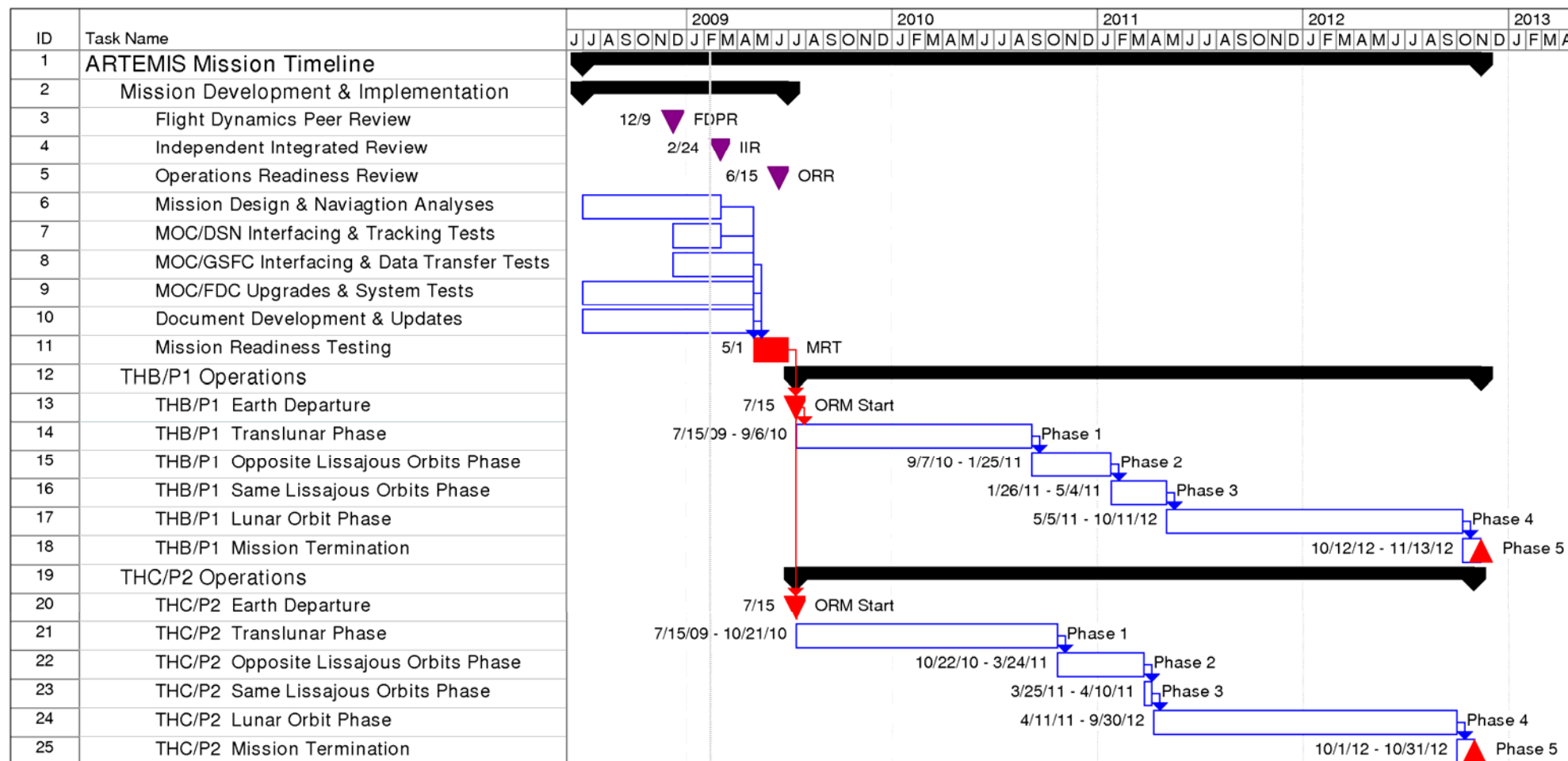


FIGURE 3.7 Lunar volatile transport. SOURCE: D.H. Crider and R.R. Vondrak, The solar wind as a possible source of lunar polar hydrogen deposits, *J. Geophys. Res.* 105:26773, 2000, ©2000 American Geophysical Union. Reproduced by permission of American Geophysical Union.



# ARTEMIS Mission Timeline





## Summary

- THEMIS prime mission accomplished by early April 2009
- ARTEMIS will provide exciting new science
- Lunar mission extension phase begins with orbit raise maneuvers in July 2009
- DSN interfacing and testing is on track
- Operations team is looking forward to continue work with DSN and appreciates the excellent support we already received